



Winston H. Hickox
Secretary for
Environmental
Protection

Department of Pesticide Regulation

Paul E. Helliker, Director
830 K Street • Sacramento, California 95814-3510 • www.cdpr.ca.gov



Gray Davis
Governor

MEMORANDUM

TO: Susan Edmiston, Sr. ERS
Worker Health and Safety Branch **HSM-00004**

FROM: Janet Spencer, Associate ERS [Original signed by J. Spencer]
Worker Health and Safety Branch

DATE: November 20, 2000

SUBJECT: WH&S BRANCH ACTIVITIES AND RESULTS OF ANALYSES RELATED
TO THE INVESTIGATION OF 49-KER-99¹ (PROJECT 9905)

Incident Chronology

On September 27, 1999, at approximately 8 AM, a crew of 8 field workers entered a 610-acre cotton field in Kern County (episode field). Seven women proceeded to rogue off-type plants in a 16-row section being grown for hybrid seed, while one man drove an enclosed-cab tractor. The field had been treated by air approximately 5 hours earlier with a mixture of DEF[®] 6 (70.5% active ingredient S,S,S-tributyl phosphorothionate (tribufos)), applied at 1 pint/acre, and Leafex 2 (18.2% active ingredient sodium chlorate), applied at 2 gal/acre. Tribufos is an organophosphorous (OP) pesticide bearing the signal word "Danger" and is a trithioalkyl cotton defoliant. The restricted entry interval (REI) following a DEF[®] 6 application is 24 hours. Permit conditions placed on September 17, 1999, prohibited field entry for harvest, tramping and raking activities for 10 days following tribufos applications, but did not address field entry for roguing. Also present in the tank mix were Air Drop, a drift control agent (75% polyethylene oxide polymer), and Activator 85, a spreader-activator (alkylaryl polyoxyethylene glycols).

The crew began the workday wearing waterproof pants and cotton gloves with rubber fingertips. The crew removed their waterproof pants around 9:30 AM, when the dew had dried from the plants. At approximately 11:30 AM, one of the grower's staff noticed the crew eating lunch and, suspecting that the field was sprayed the night before, instructed crew members to wash their hands and faces. He subsequently sent them to the shop to shower, change into clean coveralls, and bag up their contaminated clothing for laundering at the company's headquarters. Two shirts were held aside for laboratory analysis. Upon confirmation that the field had been sprayed the previous night, the crew was sent to a nearby urgent care facility. One crew member was experiencing headache and nausea at the time of examination.

Worker Health and Safety Branch (WH&S) was contacted and, at about noon on September 28 (approximately 33 hours post-application), Bernie Hernandez collected 8 dislodgeable foliar residue (DFR) samples from the episode field (400 cm²/sample). He shipped the samples and the two shirts to the CDFA Center for Analytical Chemistry in Sacramento to be analyzed for tribufos residues. Bernie collected 10 additional DFR samples around 11 AM on September 29 (approximately 56 hours post-application). At this time, the leaves were beginning to dry and



curl, and sampling was discontinued. DFR results are presented in Table 1. The shirts contained 579 µg and 6870 µg tribufos, respectively.

Table 1. Summary of DFR Results for Episode Field 49-KER-99 (µg/cm² tribufos)

| Hrs post-app | Dislodgeable Foliar Residue | | | | |
|--------------|-----------------------------|--------------------|---------|---------|-----------|
| | Average | Standard Deviation | Minimum | Maximum | n Samples |
| 33 | 0.15 ^{/a} | 0.09 | 0.07 | 0.36 | 8 |
| 56 | 0.05 ^{/b} | 0.02 | 0.02 | 0.10 | 10 |

/a 60 µg tribufos/sample

/b 20 µg tribufos/sample

All eight workers were examined for possible pesticide exposure and evaluated for pseudo and red blood cell cholinesterase depression. All workers' cholinesterase levels were within the population reference range. Seven workers were released to regular work status on September 27. One woman with symptoms of nausea, headache, and dizziness was hospitalized overnight and received treatment for OP exposure. Follow-up exams were scheduled for each worker a week later and they were encouraged to seek interim treatment should symptoms develop.

The tractor driver experienced no symptoms related to exposure. During the next three weeks, the seven women rogues all sought treatment for symptoms consistent with exposure to OPs and dermal irritants including nausea, vomiting, abdominal cramping, diarrhea, constipation, muscle soreness and weakness, headache, intermittent dizziness, shortness of breath, fatigue, chest pain, cough, sore throat, ear pain, congestion, dermal burning, rash and lesions, hair loss, and night sweats. All seven reported symptoms at their 1 week post-exposure check-ups. Five of the seven reported persistent symptoms at follow-up evaluations 2 weeks' post-exposure. Two of these five women were admitted to hospital approximately three weeks post-exposure, one on October 16 and the other on October 18.

Dr. Mike O'Malley provided phone consultation to the primary care physician on October 18 regarding the two women admitted to hospital. Dr. O'Malley said that cholinergic symptoms can persist for two to three months, as cholinesterase regenerates slowly, at about 1% per day. He advised that the two women be restricted from work for four weeks and to continue treatment for their constitutional symptoms.

Subsequently, over the next few months, the two women who were hospitalized and two more women from the crew developed a complex of neurobehavioral symptoms (including dizziness, myalgia, achiness, headaches, anxiety, nausea, gastro-intestinal distress, and respiratory problems) but none of the women developed clinically apparent delayed neuropathy. By April of 2000, three of the women had physical examinations which were largely unremarkable,

although one woman received treatment for dizziness and anxiety as recently as August, 2000. However, the fourth woman continues to date to have significant health problems associated with the exposure. She has been hospitalized several times and ongoing respiratory problems prevent her from resuming her regular work activities. Dr. O'Malley is developing a separate report titled "Neurobehavioral and Respiratory Illness Following Residue Exposure to Tribufos (DEF[®])", which details the clinical findings in this incident.

Follow-up Investigation

Violations: Fresno CAC investigation identified six violations of the California Code of Regulations, all of which contributed directly to the exposures¹. Violations included early field reentry, reentry in conflict with DEF[®] 6 labeling, failure to provide accurate and timely information regarding the application, and failure to post the field. The crop dusting service was cited for two violations related to notification of the application and the grower was cited for four violations related to field entry and field posting. The Kern County CAC issued Administrative Civil Penalties of \$4,208 and \$1,405 to the grower and crop dusting service, respectively.

DFR: For most crops, the largest source of exposure to field workers is transferable pesticide residues on the foliage. DFR samples evaluate the exposure potential as weight of pesticide per cm² of leaf surface area. However, in cotton, field entry following tribufos applications is not expected prior to harvest, when all the leaves are dessicated, leaving cotton boll residues as the only exposure source. Since cotton boll surface area cannot be evaluated, boll samples are analyzed for total weight of pesticide per unit boll weight (typically ppm). Previous investigations found an average of 2.62 ppm tribufos residues on cotton bolls (Day 1 following aerial application of DEF[®] 6 at 2.5 pints/acre)⁴. In order to compare the current DFR data in Table 1 (µg/cm²) with previous data (ppm), we need the estimated weight of a 400-cm² cotton DFR sample as a conversion factor. In investigating leaf surface area using mass-area relationships, Saiz (1990) found crop leaves averaged 0.011 g/cm² in 234 samples of four crops⁵. Using this value, we can convert the 33-hour post-application DFR of 60 µg/400 cm² (Table 1) to 14 ppm tribufos. DEF[®] 6 in the episode field was applied at 40% of the rate in the cotton boll study, yet tribufos residues in the episode field are approximately 5-fold higher than those found on cotton bolls at 24 hours post-application.

Previous studies estimated tribufos residue half-lives of 24 – 36 hours^{2,3}. The data in this study were regressed to derive a half-life for tribufos of approximately 15 hours. Initial DFR samples were collected approximately 28 hours, or 2 half-lives, after the workers were first exposed (33 hours post-application). Based on estimates of tribufos half-life of 15 – 36 hours, worker exposures in this illness investigation were potentially 2 to 4-fold higher (30 – 60 ppm tribufos), and up to 20-fold higher than potential exposure estimates using cotton boll residues (60 ppm vs. 2.62 ppm tribufos).

Toxicology Profiles: Clinical delayed neuropathic effects following human exposure have been associated with the trithioalkyl cotton defoliant merphos⁶; tribufos has been associated with these effects in animal studies⁷. DEF[®] 6 is also a strong dermal irritant⁴. Leafex 2 is also a known irritant to the skin and eyes⁸. The irritant properties likely contributed to worker symptoms of rash, lesions, hair loss, congestion, sore throat, and ear pain. One of the two women who was hospitalized three weeks post-exposure presented with lesions on her head and hair loss on September 28. Prior to roging on September 27, she retrieved her bandana from where she had left it in the episode field three days' prior. The bandana became contaminated when the episode field was sprayed early on September 27. She then wore it as a head covering for the entire morning, until the crew was pulled from the field. Penetration of OP pesticide residues to the scalp and forehead has been shown to be approximately 4 – 5 times greater than that of the forearm and hand⁹. Wearing the contaminated bandana is likely to have contributed significantly to both OP exposure and irritant symptoms.

Issues and Recommendations

DFR vs. Total Residues - Worker entry into cotton fields following application of defoliants does not usually occur until harvest, when all leaves are dessicated. This illness episode was unique in that workers were exposed to foliar rather than boll residues. Since leaves are flat, pesticide residues are distributed fairly uniformly to both leaf surfaces. The absorbent cotton lint, however, tends to distribute pesticide residues throughout the boll, reducing the amount of transferable surface residues⁴. Contact with treated foliage thus has a far greater exposure potential than does contact with treated bolls.

Previous studies of total residues ($\mu\text{g/g}$ or ppm) of tribufos on cotton bolls and results from worker exposure monitoring were used to develop transfer factors for various harvest tasks⁴. Future investigations of exposure to defoliants should include collecting cotton boll samples to compare residues with previous data. In addition, average boll weight and average cotton DFR sample weight should be evaluated to allow comparisons between transferable ($\mu\text{g/cm}^2$) and total residues (ppm) on leaf vs. boll. Cotton DFR sample weight should be evaluated when the leaves are mature, but prior to defoliant application.

Hazard Notification - A series of miscommunications and human error led to the workers being exposed. The application was originally planned for the previous day (September 26). All parties were notified when the intended application date was changed to September 27. However, the crop dusting service did not notify the grower of the completed application until approximately 30 hours later, on September 28. Meanwhile, the grower's agronomist had forgotten that the intended application date had been changed and authorized worker entry on September 27. WH&S continues to track worker exposure incidents in which failures of the hazard communication process play a major role and to develop appropriate strategies to prevent future occurrences.

REI/Permit Conditions – The largest potential human exposures are associated with cotton boll contact during harvest activities⁴. In this episode, roguingers entered the field prior to expiration of the 24-hour REI and had extensive contact with treated foliage, which presents a greater exposure hazard than do treated bolls. Permit conditions placed on September 17, 1999, prohibit field entry for harvest, tramping and raking activities for 10 days following tribufos applications, and require field posting, but do not address field entry for roguing. Had permit conditions restricted all field activities associated with cotton cultivation and harvest and the field posted accordingly, it is likely this episode would not have occurred. To prevent future illness episodes, DPR should consider either 1) adding roguing to the restricted activities in the permit conditions, or 2) establishing a 10-day REI for tribufos.

REFERENCES

1. Priority Investigation Number 49-KER-99. (2000) California Department of Pesticide Regulation, Pesticide Enforcement Branch, 1001 I Street, Sacramento, California 95814-2828
2. Maddy, K., Alexander, J., Kahn, C., and Sprock, G. (1977) A Study of the Decay Rate of DEF and Folex as a Foliar Spray in Cotton in Kern County, California, September, 1975. HS-325. California Department of Pesticide Regulation, Worker Health and Safety Branch, 1001 I Street, Sacramento, California 95814-2828
3. Sprock, G. (1977) Decline of DEF and Folex Residue on Cotton Fields in Kern and Tulare Counties September – October, 1975. HS-207. California Department of Pesticide Regulation, Worker Health and Safety Branch, 1001 I Street, Sacramento, California 95814-2828
4. Formoli, T. A., and Wang, R. G. M. (1995) Estimation of Exposure of Persons in California to Pesticide Products that Contain Tribufos (DEF). HS-1552. California Department of Pesticide Regulation, Worker Health and Safety Branch, 1001 I Street, Sacramento, California 95814-2828
5. Saiz, S. (1990) Predicting Leaf Surface Area Using Mass-Area Relationships. HS-1546. California Department of Pesticide Regulation, Worker Health and Safety Branch, 1001 I Street, Sacramento, California 95814-2828
6. Fisher, J. R. (1977) Guillain-Barre Syndrome Following Organophosphate Poisoning. JAMA, 238:1950 – 1951.
7. Lewis, C. (1999) Evaluation of S,S,S-Tributylphosphorothioate (DEF) as a Toxic Air Contaminant – Part C, Human Health Assessment (Document 101). California Department of Pesticide Regulation, Medical Toxicology Branch, 1001 I Street, Sacramento, California 95814-2828.
8. Exttoxnet, Extension Toxicology Network, Pesticide Information Profiles. <http://ace.osrt.edu/gci-bin/mfs/01/pips/sodiumch.htm>. Accessed May, 2000.
9. Maibach, H. I., Feldmann, R. J., Milby, T. H., and Serat, W. F. (1971) Regional Variation in Percutaneous Penetration in Man. Arch. Environ. Health 23, 208-211.